PAVILION SOLUTION FOR OPTIMIZATION AND CONTROL OF BOILERS WITH SCR SYSTEMS

Madhu Ramavajjala
Pavilion Technologies, Inc.

Many power producers either own or plan to install SCR systems for the reduction of NO_x emissions. While these systems are effective at achieving the required NO_x levels, instrumentation and control problems often result in higher reagent usage and O&M costs than necessary.

Moreover, excess ammonia (ammonia slip) leads to unplanned outages to clean air preheaters (in the case of hot SCR systems), reduction in catalyst lifespan and increased costs of premature catalyst replacement.

The causes of these problems can be summarized as follows:

- Unreliable or non-existent NO_x analyzers upstream of the SCR.
- Long delays in the NO_x feedback from the stack CEM.
- Inadequate characterization of SCR inlet conditions such as temperature, and gas flow.
- Lack of stack NO_x reading during CEM calibrations, maintenance, or problems.
- Inability to characterize ammonia slip in real-time.

Many of these problems can be prevented with real-time measurement and control of process inputs, upstream of the catalyst including: NOx levels, gas flow and temperature distributions.

Conventional SCR control systems rely on a simple feed-forward loop (with feed-back trim using stack NOx) developed using experimentally derived NOx versus Load curves, for ammonia injection. This results in poor control since the NOx emissions are only a weak function of unit load. Unit operating conditions such as excess air, burner tilts, mills in service etc have a significant effect on NOx. Moreover, the delay in NOx signal from stack causes inaccuracies in ammonia injection causing poor control and ammonia slip.

The proposed solution is accomplished in two steps. The optional first step is to implement a Neural Network based boiler optimization program to predict, control and optimize NOx, boiler efficiency, steam temperatures, LOI and CO. The second step in the process is to develop prediction models of the following parameters:

<u>Inlet to the SCR prediction models:</u>

- Flue gas temperature
- Flue gas flow
- Spatial distribution of temperatures and NOx concentrations

<u>Post SCR prediction models:</u>

- Ammonia slip
- NOx

<u>Control Models:</u> Using the prediction models to improve reagent utilization next requires the development of control models that use the following manipulated variables (MVs) to better control the process:

- Reagent nozzle pressure and flow control
- Nozzle selection
- Online Molarity control
- Turbulator selection (if available)

All of the models described are constructed using process data that is collected during designed experimentation and manipulation of the variables. The dynamic control models of the process accurately represent the relationships between the manipulated variables and the controlled variables.

The dynamic control models are developed using patented non-linear control and optimization algorithms that continuously determine the best setpoints for optimal operation, and automatically update the process based on new information.

These models are then installed on a computer that is connected to the data highway in the plant and will operate in both open and closed loop modes. The operator interface screens will be developed in the existing DCS if available.

One added benefit is that the ***Power Perfecter*** is designed to control and optimize during load changes when operating in closed loop mode. The split second execution times of the models makes this possible, and will greatly enhance the solution in load following units.

BENEFITS

The benefits of the proposed solution are quantified in both economic and environmental terms.

As an example, assume a 500MW coal fired boiler with base NOx emission rate of .5 lbs./MMBTU, a capacity factor of .8, a heat rate of 10,000 BTU/KWH, $1.40/MMBTU coal cost, and a cost of $0.1/lb. of ammonia. Next assume that the boiler and SCR optimization results in a 15% reduction in baseline NOx emissions to 0.425 lbs./MMBTU, a heat rate improvement of 50 BTU/KWH, SCR controls the NOx to 0.15 lbs./MMBTU and the reagent utilization is improved from 80% to 95%.

Benefits of Online Process Optimization:

• Heat Rate Improvement saves:	**$ 245,000/Yr.**
• Boiler NOx reduction saves:	**$ 186,000/Yr.**
• SCR Ammonia Optimization saves:	**$ 100,000/Yr.**
• **Annual Savings:**	**$ 531,000/Yr.**

While it is harder to quantify, improved ammonia slip control will reduce O&M costs such as:
- Improvement in catalyst life
- Reduced Fly-ash contamination
- Reduction in air preheater cleaning frequency

In summary, the ***Power Perfecter***, a proven solution for boiler optimization and control, can be extended into the optimization and control of SCR units providing increased instrument reliability, improved process control and substantial economic benefits.